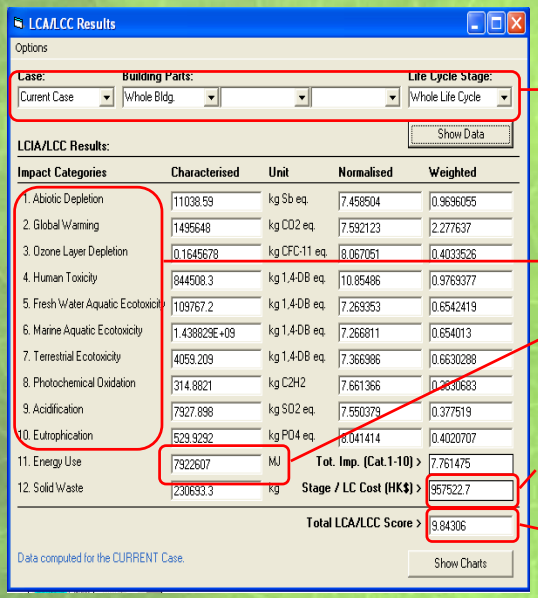
## The Life Cycle Cost (LCC)

Like any other investments, attempts to minimize environmental impact of building developments should take account of the associated costs. ***Life Cycle Cost (LCC)*** yields the present value of the current and future expenditures for the procurement of the building and for operating and maintaining the building throughout its useful life. This allows the financial implications of future savings due to additional investments made at present for enhancing performance (e.g. energy efficiency or durability of materials) to be assessed to assist the decision making.

## Interpretation

The LCEA tool developed is a computer program that can facilitate building designers to input the required data to model the building being designed; perform calculations of the environmental impacts, energy use and life cycle cost of the building; and to compare the impacts and costs of alternative designs. The program can output calculated results for different stages in the life cycle of a building, including up to the as-built stage, the operating stage and the end-of-life stage. Separate results can also be retrieved for different parts of a building, such as the impacts of the foundation, the building fabric and the services. Facilities are provided to allow the user to compare results down to individual elements level. In addition to data outputs, graphical outputs that show a comparison of alternative designs and a breakdown of the total impact by individual impact categories can be provided.



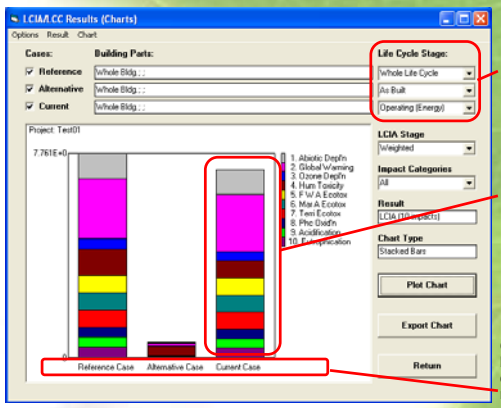

Pull-down menu allows user to specify case, building parts and stages

10 Impact Categories

Energy Use

Stage or Total Life Cycle Cost

Total LCA / LCC Combined Score




Pull-down menu allows user to specify different life cycle stages

Stacked bars showing the performance of scores summed up from 10 different impact categories

Comparison between current case, reference case and alternative case

## Where Can I Get More Information?


Energy Efficiency Office
Electrical and Mechanical Services Department
Government of the HK Special Administration Region
3 Kai Shing Street, Kowloon, Hong Kong

Tel: 2808 3465, Fax: 2890 6081
Email: lcea@emsd.gov.hk
Homepage: http://www.emsd.gov.hk

Software available for free download from the following site:
http://www.emsd.gov.hk/emsd/eng/pee/lceabc.shtml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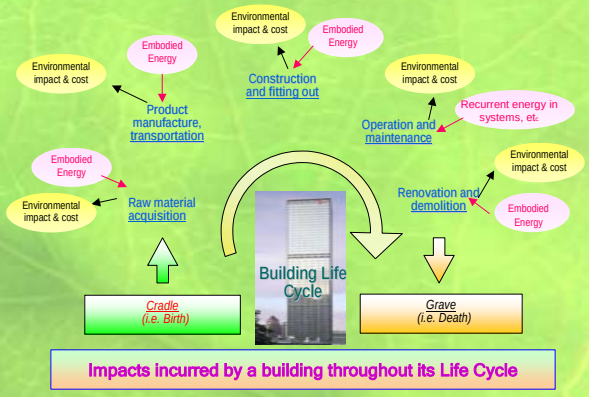
# Life Cycle Energy Analysis (LCEA) Software Tool for Commercial Building Development in Hong Kong




機電工程署 EMSD

## Building and Sustainable Development

***Sustainable Development*** is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (The World Commission on Environment and Development, 1987).

In Hong Kong, buildings are responsible for a major portion of the city's overall energy use. Demolition of buildings generates huge amount of solid waste, which is becoming a major load on our landfills. Therefore, enhancing sustainability of building developments is a key means to the pursuit of sustainable development in general. The ability to quantify the environmental impacts of a building design is a pre-requisite to this pursuit.

To enhance sustainability of building development in Hong Kong, Electrical and Mechanical Services Department (EMSD) has developed a user-friendly Life Cycle Energy Analysis (LCEA) Software Tool for assessing the environmental impacts, energy use and cost associated with the whole life cycle of building development at the design stage.

***Life Cycle Assessment (LCA)*** methodology is adopted as an objective process to evaluate the environmental burdens associated with building development by identifying and quantifying energy, material uses, releases to the environment, and to evaluate, implement opportunities, and achieve environmental improvements. The assessment includes the entire life cycle of product, process or services encompassing extracting and processing materials, manufacturing, transporting and distribution, use, reuse, maintenance, recycling and final disposal (SETAC, 1993). Internationally, the idea of LCA has been raised in:

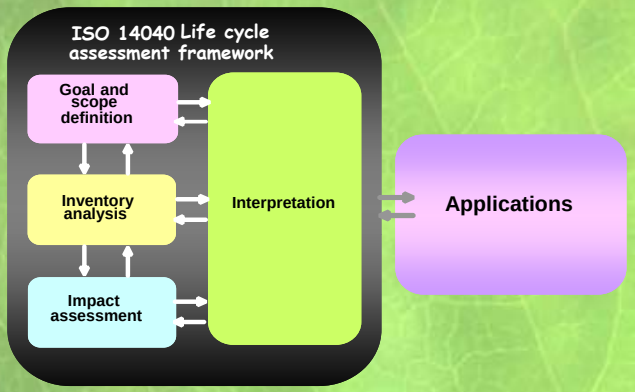
- 1992 Earth Summit at Rio
- 1997 Kyoto Protocol
- 1998 UNEP
- 2002 Earth Summit at Johannesburg

Well-known LCA programs for buildings:

1. ATHENA (Canada)
2. BEES (US)
3. EcoQuantum (The Netherlands)
4. ENVEST (UK)

## Stages of LCA under ISO 14040

***Goal and Scope Definition***: State intended application, reasons for doing LCA and to whom the LCA results are communicated; and define system boundary, assessment method, data requirement, functional units, assumptions, limitations, etc.
***Inventory Analysis***: Collect the economic flows and environmental interventions data for each unit process within the system boundary. The analysis yields a list of resources input and emissions from the involved processes.
***Impact Assessment***: Include: sections of impact categories and indicator; (2) Classification of inventory data into impact categories; (3) Characterization of inventory data within each category; and optionally: (4) Normalization; (5) Grouping; and (6) Weighting the characterized results.
***Interpretation:*** Include: making observations from the results to identify improvement opportunities or compare alternative processes.



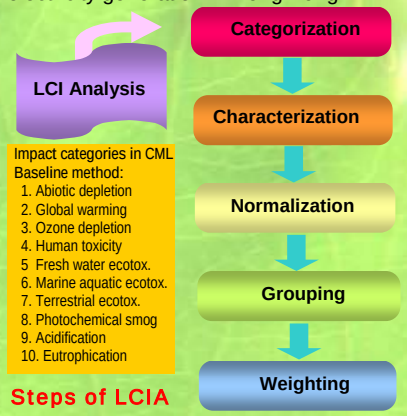

## The Life Cycle Inventory (LCI) Analysis

***Life Cycle Inventory (LCI) Analysis*** yields a long list of the quantities of all the natural resources consumed and the emissions produced in various stages of the complete life cycle of a product, from cradle to grave. The LCI result is dependent on the types and quantities of natural resources (including fossil fuels) and other materials used in the production of the product; the modes and distances of transportation involved; the way in which the product is used and its lifespan; and how the product is finally disposed of. These factors vary from one country or region to another, dependent on the availability of the required resources in the region, the technologies employed in the production processes, and whether the consumed product is locally produced or imported. Whilst the LCI result is a complete account of the quantities of resources consumed and emissions incurred during the life cycle of a product, the long list of quantities is difficult to interpret.

## The Impact Assessment (LCIA)

***The Assessment*** follows the LCI analysis first ***categorizes*** the impacts (resources consumption and emissions) into a range of impact categories. The ***Characterization*** step is then done, which converts the quantities of various types of impacts under each category into equivalent quantities of a reference impact (e.g. methane into an equivalent amount of $CO_2$ under the global warming category), yielding one single impact indicator for each impact category. Each impact indicator retains the unit of measurement of the quantity.
The ***Normalization*** step converts the impact profile (the set of impact indicators, one for each impact category), into a set of dimensionless numbers. Typical normalization factors used are the total quantity of each type of impact incurred in a region or the whole world in a year, on the whole or on per capita basis. A normalized impact indicator reflects the proportional contribution of the product to the total impact of the same type in the region, and hence the seriousness of the impact the product would incur.
An effective ***Grouping*** step is required for the convenience of further study proceeding and data analysis.

To facilitate decision making, the normalized impact indicators may be ***weighted*** to yield a single, all-embracing impact indicator, through the use of a set of weighting factors. Derivation of the weighting factors is typically through solicitation of expert opinions. In this study, the CML Baseline 2000 LCIA method is adopted. In addition to the ten impact categories embraced by the method, two additional impact indicators are provided for reference: life cycle energy use (including embodied and operating energy use) and solid waste generation. The normalization factors used are based on 1 TJ of electricity generation in Hong Kong.




## Establishment of LCA/LCC data

Surveys were conducted on components and materials used in 28 recently completed commercial buildings in Hong Kong, which helped to identify the range of components and materials that would dominate the total environmental impacts of buildings. Surveys had also been conducted to find out the additional impacts that would be incurred during the construction stage; and the countries from which building materials and services equipment were imported into Hong Kong for building construction. Other supporting data had also been collected from different sources, such as the type of fuel for production processes, the fuel mix used in various countries for electricity generation and the mode and distance of transport involved for importing building and system components and materials from these countries, etc.

Top 10 dominant building materials in respect of LCI in the database:

1. Concrete
2. Reinforcing Bar
3. Plaster, Render and Screed
4. Galvanised Steel
5. Tiles
6. Stones
7. Aluminium
8. Structural Steel
9. Access Floor Panel
10. Stainless Steel

Top 10 building services systems & components with greatest LCI in the database:

1. Power cables
2. Busbar trunking or busducts
3. Chillers
4. Air conditioning duct work & fitting and insulation
5. Chilled water systems including pipework excluding chiller
6. MCB and MCCB distribution boards
7. Sprinkler systems including pipework
8. AHU/PAUs
9. Submain conduits and trunkings
10. Luminaries